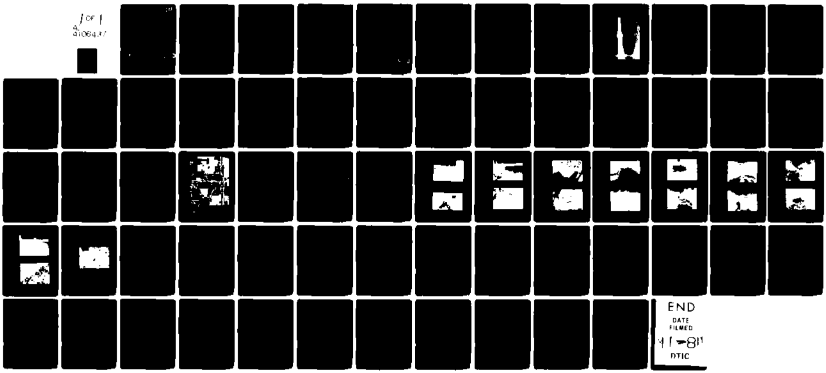
AD-A106 437 BLACK AND VEATCH KANSAS CITY MO F/G 13/13
NATIONAL DAM SAFETY PROGRAM. KERNODLE LAKE DAM NUMBER 1 (MO 201--ETC(U)
SEP 79 P R ZAMAN, E R BURTON, H L CALLAHAN DACW43-79-C-0040

UNCLASSIFIED NL

1 OF 1
AD
A106437



LEVEL II

# MISSOURI-KANSAS CITY BASIN

AD A106437

KERNODLE LAKE DAM NO. 1

JACKSON COUNTY, MISSOURI

MO 20140

# PHASE 1 INSPECTION REPORT
# NATIONAL DAM SAFETY INSPECTION

DTIC FILE COPY

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

DTIC
ELECTE
NOV 2 1981
S D
D

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER 1979



81 10 26 061

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

# REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

| | |
|---|---|
| 1. REPORT NUMBER | 2. GOVT ACCESSION NO. AD-A106 |
| 3. RECIPIENT'S CATALOG NUMBER 437 | |
| 4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Kernodle Lake Dam #1 (MO 20140) Jackson County, Missouri | 5. TYPE OF REPORT & PERIOD COVERED Final Report |
| | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) Black & Veatch, Consulting Engineers | 8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-0040 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101 | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101 | 12. REPORT DATE September 1979 |
| | 13. NUMBER OF PAGES Approximately 60 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | 15. SECURITY CLASS. (of this report) UNCLASSIFIED |
| | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

National Dam Safety Program. Kernodle Lake Dam Number 1 (MO 20140), Missouri - Kansas City Basin, Jackson County, Missouri. Phase I Inspection Report.

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

MISSOURI-KANSAS CITY BASIN

KERNODLE LAKE DAM NO. 1

JACKSON COUNTY, MISSOURI

MO 20140

# PHASE 1 INSPECTION REPORT
# NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

**St. Louis District**

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

SEPTEMBER 1979

**DEPARTMENT OF THE ARMY**
**ST. LOUIS DISTRICT, CORPS OF ENGINEERS**
210 NORTH 12TH STREET
**ST. LOUIS, MISSOURI 63101**

REPLY TO
ATTENTION OF

SUBJECT: Kernodle Lake Dam No. 1 Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Kernodle Lake Dam No. 1 (MO 20140).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass a 10-year frequency flood without overtopping of the dam. The spillway is, therefore, considered to be unusually small and seriously inadequate.

2) Overtopping could result in dam failure.

3) Dam failure significantly increases the hazard to life and property downstream.

Submitted By: SIGNED — Chief, Engineering Division — Date: 28 FEB 1980

Approved By: SIGNED — Colonel, CE, District Engineer — Date: 28 FEB 1980

| Accession For | |
|---|---|
| NTIS GRA&I | X |
| DTIC TAB | ☐ |
| Unannounced | ☐ |
| Justification | |
| By | |
| Distribution/ | |
| Availability Codes | |
| Dist | Avail and/or Special |
| A | |

DTIC
ELECTE
NOV 2 1981
S D
D

KERNODLE LAKE DAM NO. 1

JACKSON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20140

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

SEPTEMBER 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

| | |
|---|---|
| Name of Dam | Kernodle Lake Dam No. 1 |
| State Located | Missouri |
| County Located | Jackson County |
| Stream | Tributary to Blue River |
| Date of Inspection | 6 September 1979 |

Kernodle Lake Dam No. 1 was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would potentially cause damage to two buildings, two improved roads, a lake and a park area within the estimated damage zone, which extends approximately two miles downstream of the dam.

Our inspection and evaluation indicates the spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will pass neither 50 nor 100 percent of the probable maximum flood without overtopping, but will pass 5 percent of the probable maximum flood. The spillways will not pass the 10-year flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded, the characteristics of upstream reservoirs, and the downstream hazard zone, 50 percent of the probable maximum flood is the appropriate spillway design flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Deficiencies visually observed by the inspection team were brush and tree growth on both slopes of the embankment, areas of erosion on the embankment and at the downstream end of the emergency spillway, and a 120 foot long area of excessively steep slope on the downstream face, beginning about 75 feet left of the siphon.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

Paul R. Zaman

Paul R. Zaman, PE
Illinois 62-29261

Edwin R. Burton

Edwin R. Burton, PE
Missouri E-10137

Harry L. Callahan

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
KERNODLE LAKE DAM NO. 1

TABLE OF CONTENTS

LIST OF PLATES



LIST OF PHOTOGRAPHS

## LIST OF PHOTOGRAPHS



## APPENDIX

## SECTION 1 - PROJECT INFORMATION

### 1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Kernodle Lake Dam No. 1 be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

### 1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The Kernodle Lake Dam No. 1, hereafter referred to in this report as Dam No. 1, is an earthen structure located in southwestern Jackson County, Missouri on a tributary to the Blue River. The principal purpose for this dam is recreation. Dam No. 1 is one of two reservoirs located on property owned by Mr. John Kernodle of Kansas City, Missouri. The dam is 25 feet wide at the crest, 1,000 feet long, and 28 feet high. The dam has an emergency spillway located at the right abutment, and a principal spillway located just to the left of the emergency spillway. The embankment is protected on the upstream face by scattered rock, trees, and brush. The crest is characterized by sparse grass cover, weeds, and vehicular path. The downstream face is covered with dense brush and trees.

(2) A concrete emergency spillway is located at the right abutment. It consists of a concrete approach and discharge channel with concrete block sidewalls. The spillway approach and discharge channels have rectangular cross sections.

(3) The principal spillway consists of a 12-inch vitrified clay discharge pipe with trash screen. The 12-inch pipe discharges into the discharge channel of the emergency spillway.

(4) An 8-inch cast iron siphon is located approximately 500 feet left of the emergency spillway. The siphon is valved at the downstream embankment toe and upstream face.

(5) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in southwestern Jackson County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Grandview, Missouri in Section 10 of T47N, R33W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Kernodle Lake Dam No. 1 has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial, and commercial facilities, and to important public utilities, main highways, or railroads. For Dam No. 1 the estimated flood damage zone extends downstream for approximately two miles. Within the damage zone are two buildings, a lake, a park, and two improved road crossings.

e. Ownership. The dam is owned by Mr. John Kernodle, 4100 E. 119th, Kansas City, Missouri, 64137, Telephone (816) 763-7000.

f. Purpose of Dam. The dam forms a 19-acre recreational lake.

g. Design and Construction History. Data relating to the design were not available. The owner reported that the structure was constructed in 1967 by James Gould Construction Company.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, capacity of the uncontrolled principal and emergency spillways, and the operation of the siphon all combine to maintain a relatively stable water surface elevation. According to the owner, the lake level is drawn down to an arbitrary useful elevation below the principal spillway crest, through operation of the siphon, subsequent to heavy rains and prior to winter.

i. Maintenance. Infrequent maintenance of this dam has been performed according to the owner. Reconstruction of the emergency spillway and a section of the embankment crest near the left abutment was completed a few weeks prior to inspection of the structure.

## 1.3 PERTINENT DATA

a. Drainage Area - 935 acres (includes 784 acres of area above several upstream impoundments).

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled principal spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated combined ungated spillway capacity at maximum pool elevation -290 cfs (Probable Maximum Flood Pool El.892.7).

c. Elevation (Feet above m.s.l.).

(1) Minimum top of dam - 890.1 ± (see Plate 3)

(2) Emergency spillway crest - 888.0

(3) Principal spillway crest - 887.1

(4) Streambed at toe of dam - 861.9

(5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 1,300 feet ±

(2) Length of normal pool - 1,200 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 275

(2) Emergency spillway crest - 233

(3) Principal spillway crest - 217

(4) Design surcharge - Unknown.

f. Reservoir Surface (Acres).

(1) Top of dam - 21

(2) Emergency spillway crest - 19

(3) Principal spillway crest - 19

g. Dam.

(1) Type - Earth embankment

(2) Length - 1,000 feet

(3) Height - 28 feet ±

(4) Top width - 25 feet

(5) Side slopes - upstream face 1.0 V on 2.5 H and downstream face varies from 1.0 V on 2.2 H to 1.0 V on 2.6 H.

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

(10) Internal drainage system - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Emergency Spillway.

(1) Type - Chute spillway with rectangular cross section.

(2) Bottom width of chute - 11.3 feet

(3) Channel side slopes - Vertical.

(4) Crest elevation - 888.0 feet m.s.l.

(5) Gates - None.

(6) Upstream channel - Not applicable.

(7) Downstream channel - Open channel comprised of broken shale and limestone.

j. Principal Spillway.

(1) Type - 12-inch diameter vitrified clay pipe with trash screen and inlet weir.

(2) Inlet weir crest elevation - 887.1

(3) Gates - None.

(4) Upstream channel - None.

(5) Discharge pipe - 12-inch diameter vitrified clay pipe.

(6) Downstream channel - Open channel comprised of broken shale and limestone.

k. Regulating Outlets - An 8-inch diameter cast iron siphon with control valves on both upstream and downstream ends is located approximately 500 feet left of the emergency spillway. Discharge from the siphon is into an unprotected pool downstream of the dam embankment.

## SECTION 2 - ENGINEERING DATA

### 2.1 DESIGN

Design data were unavailable.

### 2.2 CONSTRUCTION

According to the owner, the dam was constructed in 1967 by James Gould Construction Company. Further construction data were unavailable.

### 2.3 OPERATION

According to the owner, the siphon is periodically operated to lower the pool level below principal spillway crest subsequent to heavy rains and prior to winter.

### 2.4 GEOLOGY

Design drawings, construction records, and geologic reports for the dam and reservoir sites were not available. The geologic conditions were determined from existing general data on the site and from visual observations made during the inspection of the dam.

The dam is located in a broad valley formed in interbedded limestones and shales that are overlain by soils derived from bedrock and loess. Alluvial soils are present along the streams. The bedrock in the area consists of Pennsylvanian age shales and limestones of the Desmoinesian Series, Kansas City Group, Linn and Zarah subgroups. The surficial soils have been mapped by the Soil Conservation Service as Sharpsburg, on the ridges and interstream divides, and as Polo-Sogn soil association complex on the slopes and in the valleys. The foundation and the abutments of the dam are anticipated to be Polo-Sogn soil overlying interbedded limestone and shale units. It is anticipated that pervious alluvial soils were removed from the foundation prior to construction.

The Sharpsburg soil is developed from loess and the Polo-Sogn soil assocation is developed from loess or residuum over shales or weathered limestones. The alluvial soils consist of sand, gravel, and various size fragments of weathered bedrock along and within the stream channel.

### 2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. No engineering data were available upon which to make a detailed assessment of the design, construction and operation. Seepage and stability analyses comparable to the requirements of the

"Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Dam No. 1 was made on 6 September 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology, hydraulic engineering, and geotechnical engineering. This dam is in fair condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed several deficiencies during the visual inspection of this structure. No seepage was observed, however, approximately 90 percent of the embankment length, including the downstream slope and toe and left abutment, could not be observed due to extremely dense brush and tree growth which hampered comprehensive visual inspection of the structure. Scattered rock, brush, and trees, with one particularly large tree, comprise the upstream slope protection. A sparse grass cover and vehicle track characterize the embankment crest with minor erosion of abutment material. The downstream slope is protected by dense brush and trees as previously mentioned. The downstream embankment slope, over a width parallel to the centerline of about 120 feet and beginning about 75 feet left of the siphon, is excessively steep. Although the slope was not measured, it appeared to be less than 2 to 1. This condition of excessively steep slope could lead to failure under conditions of extreme high water or overtopping. Erosion to a depth in excess of 3 feet exists in the left portion (section about 200 feet in length parallel to the centerline) of the downstream slope of the dam. Erosion on the upstream slope consists of minor sloughing up to 2 feet deep in isolated spots due to wave action and undercutting The upstream erosion protection is inadequate. The material being eroded is primarily residual CL. Residual shale is being eroded along the right emergency spillway wall. Repair work has taken place in an area 50 feet in length along the crest of the dam and in the area of the spillways. The repaired area has neither riprap nor grass to provide erosion protection. An area of erosion and rutting was observed on the left abutment. These areas of erosion and evidences of repair are indicators that overtopping may have occurred. There is no evidence of sliding, cracking, settlement, sinkholes, potholes, or animal burrows.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. The emergency spillway consists of an ungated concrete chute with concrete block retaining walls. The emergency spillway will act as a weir. The width of the spillway is 11.3 feet, while the height of the walls ranges from 12 inches to 17 inches. Because the spillway was just recently constructed,

the backfill and grading around the retaining walls is not yet complete. It was impossible to tell if any of this material was being eroded. The only erosion observed was minor erosion at the downstream end of the spillway chute. The recently constructed discharge channel in this area may prevent future erosion. The spillway channel appears to be in good condition with no visible cracks in the chute and no apparent movement in the joints between the concrete blocks in the walls. The emergency spillway channel contains no wall drains or floor weepholes and is clear of obstructions to flow.

The principal spillway consists of a 12-inch vitrified clay outlet pipe and headwall which discharges into the emergency spillway on the downstream side of the embankment. A trash screen covers the entrance on each of three sides. The outlet pipe is constructed with a bend through the embankment. The portion of the conduit which was exposed, about 20 feet upstream from the outlet point, appeared in good condition with no apparent movement at the joints and no leakage into or out of the pipe. A large plank was jammed inside the pipe at the bend.

The 8-inch cast iron siphon pipe discharges into an unprotected pool downstream of the embankment. About 50 percent of the siphon pipe was observable. This portion of the pipe appeared in good condition with no evidence of leakage. The siphon pipe alinement through the embankment includes several bends. The siphon is operated by a valve at each of the upstream and downstream ends. The operating valves also appeared to be in good condition. The siphon outlet pool has caused minor erosion downstream of the toe of the embankment.

No toe drains or relief wells were observed.

d. Geology. Observations of exposed material in the downstream channel and eroded areas indicated that the foundation material consists of weathered shale with limestone units. Observations of both exposed regions and probing indicated the embankment to be primarily residual CL material. The emergency spillway is constructed at the right abutment in soil and weathered shale. It discharges into an unlined stream channel that parallels the toe of the embankment until it intersects the original stream channel. The discharge channel is formed in interbedded shale and limestone. The limestones are horizontal and thin bedded with two sets of intersecting, vertical, closely spaced, closed joints. The shales are soft and blocky and are easily eroded. Approximately 80 feet down the discharge channel from the end of the emergency spillway chute, a thin limestone unit (12 inches thick) forms a ledge with a drop of approximately 8 feet into a basin formed in the underlying shale. No seepage was observed from any of these units. However, recent rains could have obscured such seepage.

e. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. There is a minor amount of sediment buildup along the shoreline.

f. Downstream Channel. The channel downstream of the spillway is a natural open channel to the original streambed.

## 3.2 EVALUATION

During the inspection several deficiencies which warrant attention were observed. Should the embankment be subjected to high lake levels and correction of slope deficiencies be ignored, the embankment may fail. Based on partial observation of the structure, seepage appears to be unlikely to become a problem in the foreseeable future. The erosion of the embankment could lead to failure. Dense brush and tree growth prevents the establishment of grasses which provide more effective erosion protection. The upstream slope would particularly benefit from the establishment of proper riprap protection. The recent embankment repair section, if left unprotected on the crest and downstream slope, will deterioriate with time unless proper vegetal cover is established. The erosion of the channel downstream of the emergency spillway chute could potentially be a problem. Rock erosion protection in the discharge channel is warranted. The erosion downstream of the siphon pipe outlet is not expected to become a problem. The plank should be removed from the principal spillway pipe to prevent clogging.

## SECTION 4 - OPERATIONAL PROCEDURES

### 4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, capacity of the uncontrolled principal and emergency spillways, and the operation of the siphon. The owner reported that the siphon is opened during periods of heavy rainfall or other periods when the lake level is high.

### 4.2 MAINTENANCE OF DAM

The owner reported that there is no regularly scheduled program for maintenance.

### 4.3 MAINTENANCE OF OPERATING FACILITIES

Reconstruction of the emergency spillway and a section of the embankment crest near the left abutment was completed a few weeks prior to the inspection of the dam.

### 4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing system or preplanned scheme for warning occupants of the hazard zone below this dam.

### 4.5 EVALUATION

A maintenance program should be developed in conjunction with the improvements previously suggested. Both the slopes and the crest of the embankment should be mowed. Trees should be removed before they become large. Riprap should be maintained, and if necessary replaced, to control erosion.

## SECTION 5 - HYDRAULIC/HYDROLOGIC

### 5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

b. Experience Data. The drainage area and lake surface area were developed from the USGS Grandview Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The emergency spillway appears to be in good condition. The lake level at the time of the inspection was below the inlet level and there was no flow through the channel. Minor erosion was observed at the downstream end of the spillway chute.

(2) The principal spillway was partially blocked by a large plank jammed inside the spillway pipe. Otherwise, the spillway appears to be in good condition. The lake level at the time of the inspection was below the upstream pipe invert and there was no flow through the pipe. No erosion was observed at either the upstream or downstream end of the principal spillway.

(3) The siphon pipe provides a possible means for evacuating the pool depending upon the relative elevations of the water level and the pipe inlet and outlet. .

(4) Abnormally large spillway discharges may have an adverse effect on the integrity of the dam. These flows could potentially cause undercutting of the downstream toe and erosion along the right side of the emergency spillway.

d. Overtopping Potential. Hydraulic data for impoundments upstream of Dam No. 2, which is immediately upstream from Lake No. 1, were not obtained due to denial of access by the owner of the upstream property. An estimated inflow hydrograph was developed and added to the hydrograph of the runoff directly flowing into Lake No. 2. The estimate was based upon adjusting the 200 square mile, 24 hour, Probable Maximum Precipitation Index to reflect experienced outflow/ inflow ratios of similar impoundments and drainage areas. The historical difference in inflow and outflow peaks was also analyzed. The resultant estimated hydrograph is developed in the output for HEC-1. The emergency and principal spillways discharging simultaneously will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions

that are reasonably possible in the region. The spillways will pass 5 percent of the probable maximum flood without overtopping the dam. The spillway will not pass the 10-year flood. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded, the characteristics of upstream reservoirs, and the downstream hazard zone, 50 percent of the probable maximum flood is the appropriate spillway design flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 6,440 cfs of the total discharge from the reservoir of 6,730 cfs. The estimated duration of overtopping is 14.5 hours with a maximum depth of 2.6 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood which would overtop the dam would be 2,840 cfs of the total discharge from the reservoir of 3,060 cfs. The estimated duration of overtopping is 10.9 hours with a maximum depth of 1.9 feet. Failure of upstream water impoundments shown on the USGS maps would have a significant impact on the hydrologic and hydraulic analyses. There is evidence that the soils typical of the embankment surfaces tend to erode. Prolonged overtopping of the embankment is believed capable of causing erosion which could lead to failure.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. There are two buildings, a lake, a park, and two improved road crossings downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur. The Blue River Parkway downstream of the dam is city owned park land. Development has been restricted in the 100-year flood plain of the Blue River.

## SECTION 6 - STRUCTURAL STABILITY

### 6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Post Construction Changes. According to the owner, compacted CL material was placed in an eroded area of the embankment crest, near the left abutment in August, 1979. The repaired area has neither riprap nor grass to provide erosion protection.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. The primary concern is the danger of overtopping the dam due to the hydraulic inadequacy of the spillways. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are brush and tree growth on the embankment, areas of erosion over the embankment and at the downstream end of the emergency spillway, and an area of excessively steep slope. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. However, seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed to implement remedial measures recommended in paragraph 7.2b as soon as possible. The items recommended in paragraph 7.2a should be analyzed on a high priority basis by the owners of this dam.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam or identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analyses.

7.2 REMEDIAL MEASURES

a. Alternatives. According to the estimated hydrologic/hydraulic analysis, the present spillway has the capacity to pass a discharge of 5 percent of the probable maximum flood without overtopping the embankment. A detailed hydrologic/hydraulic analysis should be performed subsequent to data collection on the upstream impoundments and hydraulic structures. The estimated analysis provided in this inspection is not

adequate for proper alternative determinations. In order to pass 50 percent of the probable maximum flood as required by the Recommended Guidelines, the spillway size and/or height of dam would need to be increased or the lake level would need to be lowered to increase storage capacity.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

(1) An improved maintenance program to remove and control the growth of brush and trees on the embankment should be developed. Removal of large trees should be under the guidance of an engineer experienced in the design and construction of earthen dams. Indiscriminate clearing could jeopardize the safety of the dam. Grass cover on the embankments should be cut periodically.

(2) Erosion protection should be maintained and added as necessary on the upstream slope of the dam to prevent erosion of embankment material due to wave action.

(3) The plank should be removed from the principal spillway pipe to prevent clogging.

(4) A detailed inspection of the dam should be made periodically by an engineer experienced in design and construction of dams. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increases.

(5) Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

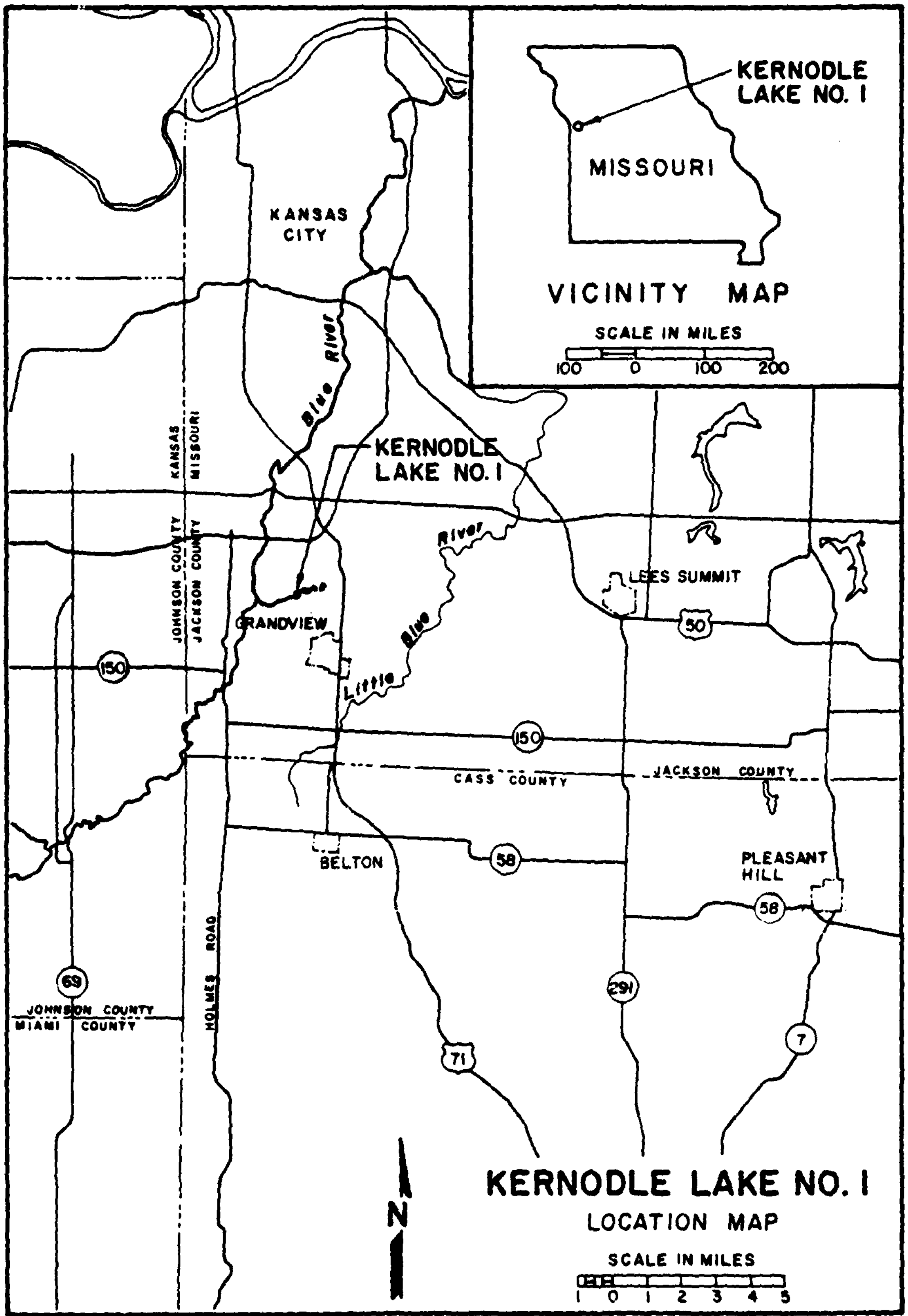
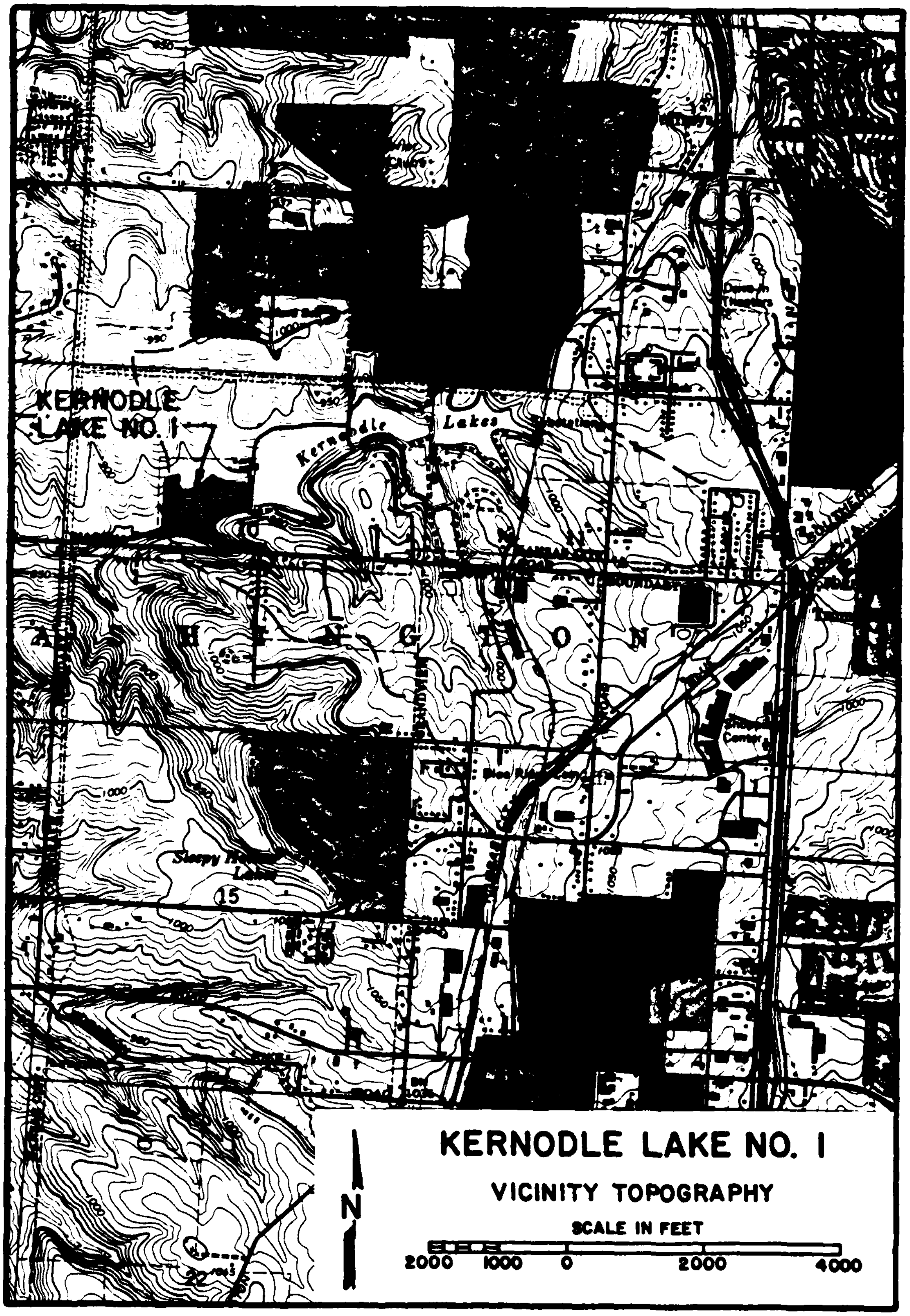

KERNODLE
LAKE NO. 1
MISSOURI
VICINITY MAP
SCALE IN MILES
100 0 100 200
KANSAS
CITY
Blue River
KERNODLE
LAKE NO. 1
KANSAS
MISSOURI
JOHNSON COUNTY
JACKSON COUNTY
River
Little Blue
LEES SUMMIT
50
GRANDVIEW
150
150
CASS COUNTY
JACKSON COUNTY
BELTON
58
PLEASANT
HILL
58
69
JOHNSON COUNTY
MIAMI COUNTY
HOLMES ROAD
291
71
7
N
KERNODLE LAKE NO. 1
LOCATION MAP
SCALE IN MILES
1 0 1 2 3 4 5

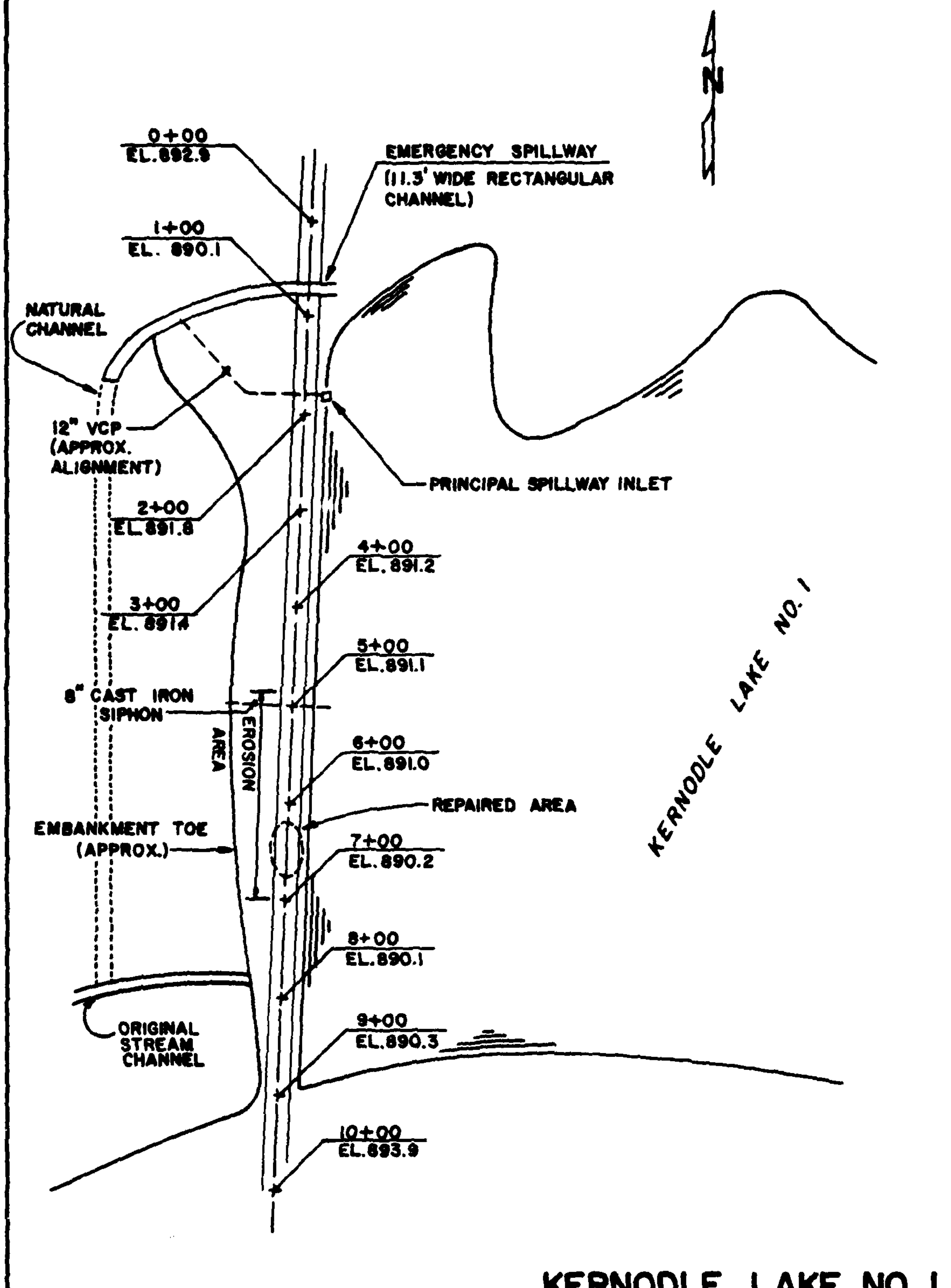
PLATE 1




KERNODLE LAKE NO. I

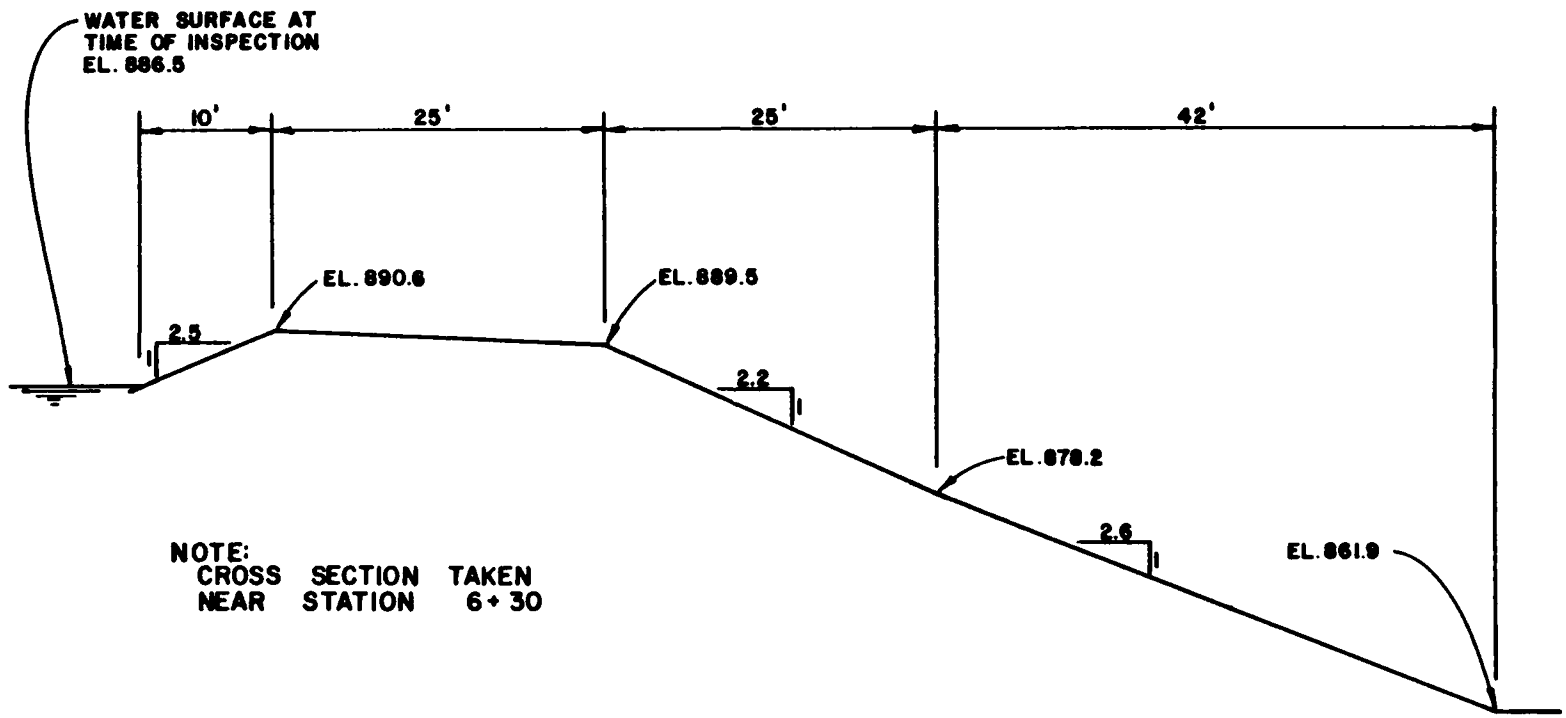
VICINITY TOPOGRAPHY

PLATE 2




KERNODLE LAKE NO. 1
PLAN

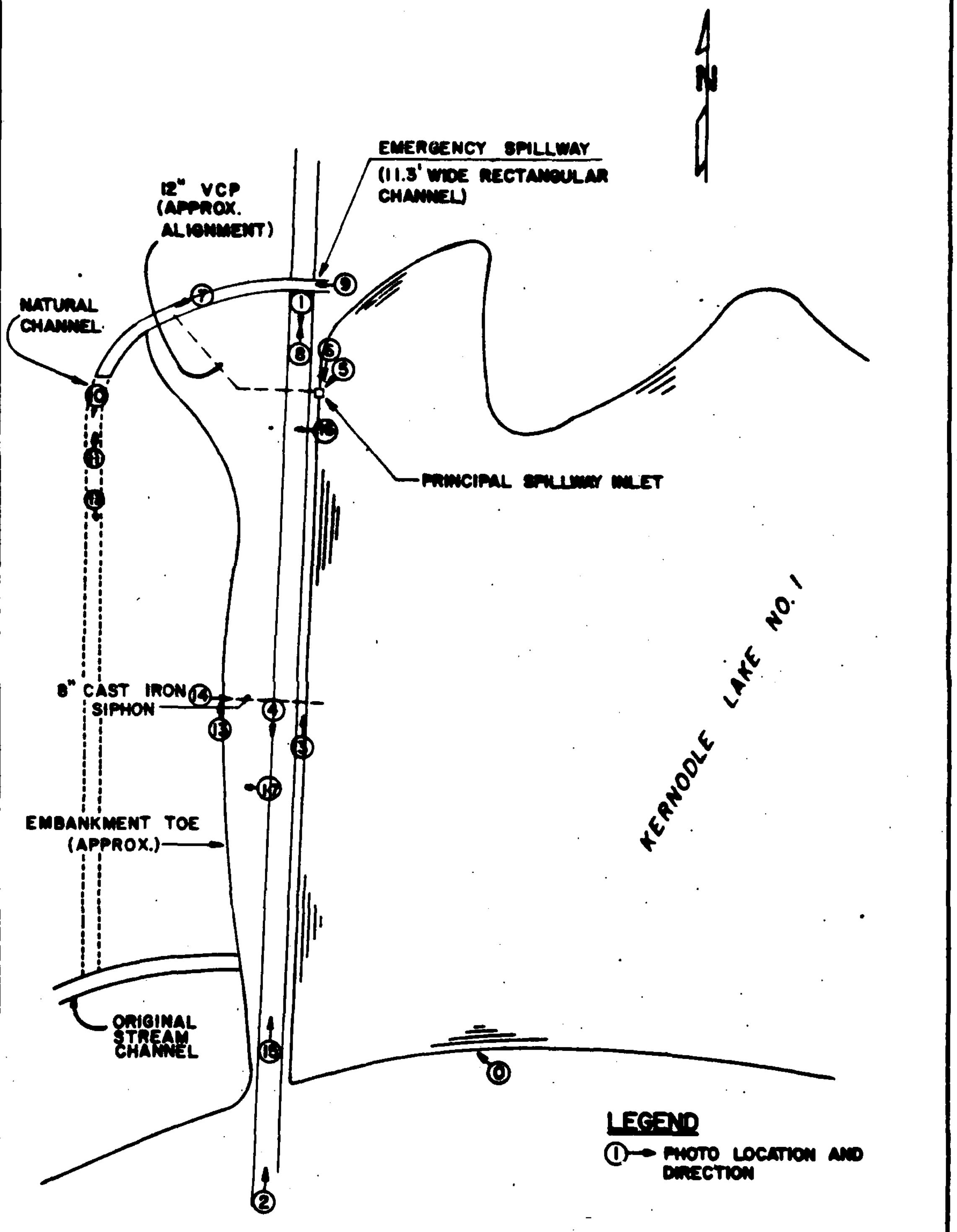
PLATE 3




NOTE:
CROSS SECTION TAKEN
NEAR STATION 6+30

SECTION DATA OBTAINED
FROM FIELD SURVEY.

# KERNODLE LAKE NO. 1
# EMBANKMENT CROSS SECTION




KERNODLE LAKE NO. 1
PHOTO INDEX

PLATE 5

PHOTO 1: CREST OF DAM LOOKING SOUTH

PHOTO 2: CREST OF DAM VIEWED FROM LEFT ABUTMENT

PHOTO 3: UPSTREAM FACE OF DAM AND SIPHON

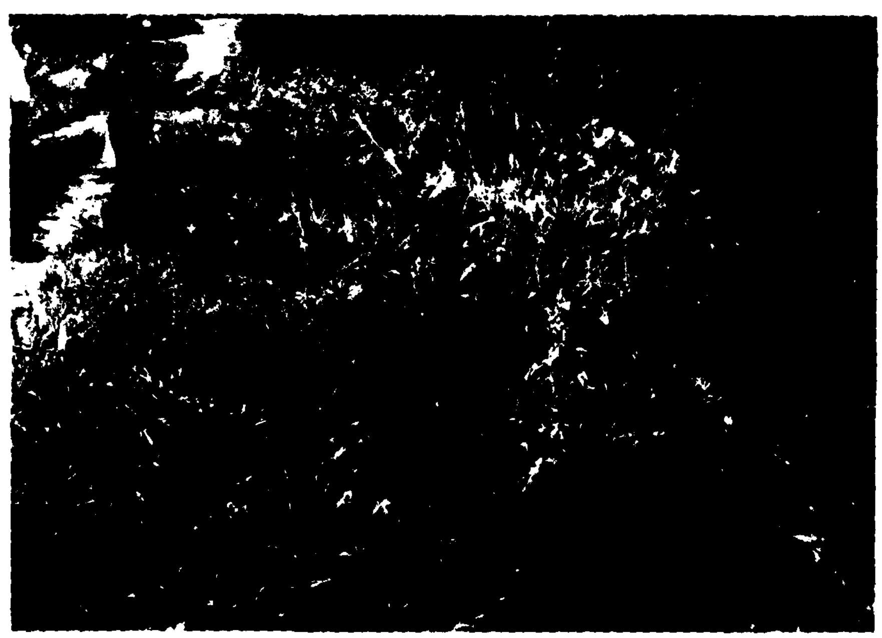


PHOTO 4: DOWNSTREAM SLOPE OF DAM

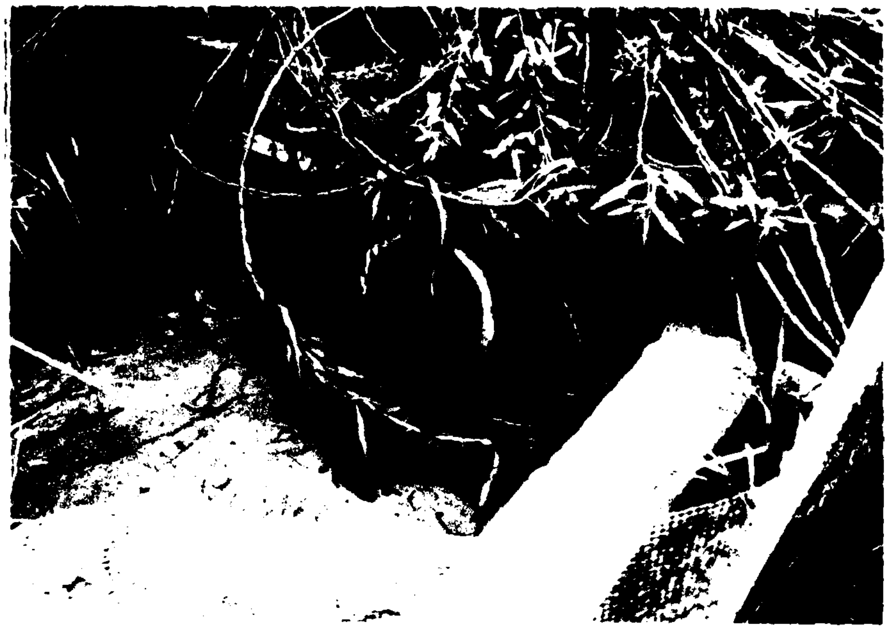


PHOTO 5: PRIMARY OUTLET PIPE ENTRANCE

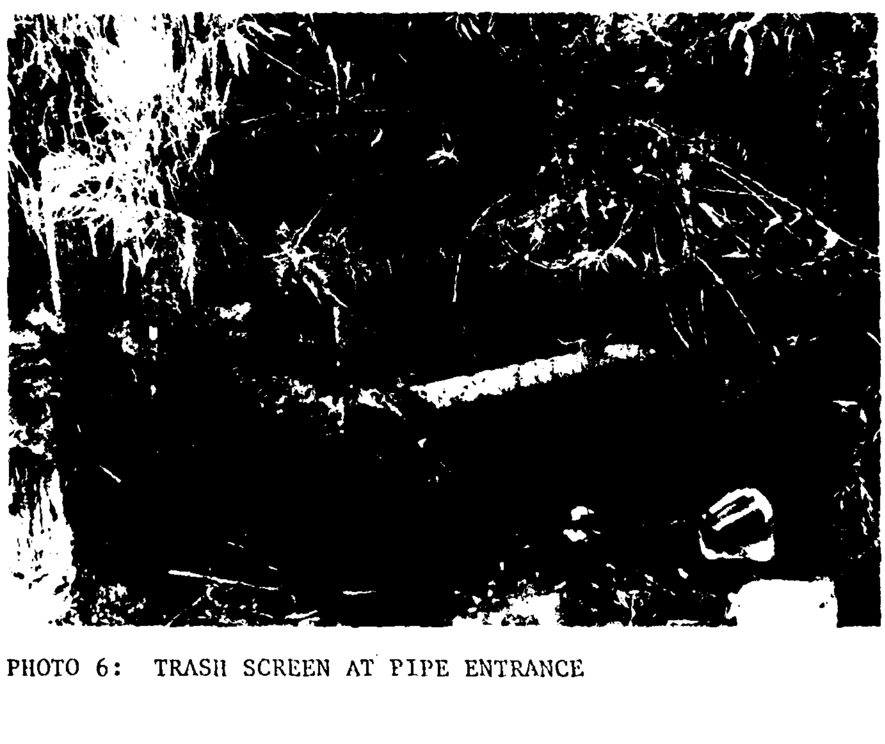


PHOTO 6: TRASH SCREEN AT PIPE ENTRANCE

PHOTO 7: OUTLET PIPE DOWNSTREAM END AND EMERGENCY SPILLWAY CHUTE

PHOTO 8: EMERGENCY SPILLWAY VIEWED FROM CREST OF DAM

PHOTO 9: EMERGENCY SPILLWAY CREST LOOKING DOWNSTREAM

PHOTO 10: CHANNEL BELOW EMERGENCY SPILLWAY CHUTE

PHOTO 11: NATURAL CHANNEL OVERFALL DOWNSTREAM FROM EMERGENCY SPILLWAY (TOP LIMESTONE SLAB ABOUT 12 INCHES THICK AND HEIGHT OF DROP ABOUT 8 FEET)

PHOTO 12: NATURAL CHANNEL BELOW OVERFALL

PHOTO 13: SIPHON CONTROL VALVE BELOW TOE OF DAM

PHOTO 14: SIPHON OUTLET POOL LOOKING TOWARD TOE OF DAM


PHOTO 15: RECENT REPAIR WORK ON CREST OF DAM


PHOTO 16: EROSION ON FACE OF DAM

PHOTO 17: EROSION ON BACK SLOPE OF DAM

# APPENDIX A

# HYDROLOGIC COMPUTATIONS

## HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph and HEC-1 (1) were used to develop the inflow hydrographs, and hydrologic inputs as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

| | |
|---|---|
| 200 square mile, 24 hour rainfall inches | - 24.8 |
| 10 square mile, 6 hour percent of 24 hour 200 square mile rainfall | - 101% |
| 10 square mile, 12 hour percent of 24 hour 200 square mile rainfall | - 120% |
| 10 square mile, 24 hour percent of 24 hour 200 square mile rainfall | - 130% |

Because the hydraulic data for impoundments upstream of Dam No. 2 were unavailable, an estimated inflow hydrograph was developed and added to the hydrograph of the runoff directly flowing into Lake No. 2. The outflow and inflow peaks were determined for impoundments of similar size and drainage area. The outflow/inflow ratios and the time difference between the peak inflow and peak outflow were determined for each of these impoundments. An analysis of the results showed that the outflow/inflow ratio was approximately 0.90 for 50 percent and 100 percent of the probable maximum precipitation and 0.80 for smaller percentages of the probable maximum precipitation. The 200 square mile, 24 hour, Probable Maximum Precipitation Index was multiplied by these ratios. The analysis of the similar impoundments showed that the change in the time between the peak inflow and peak outflow was small. Therefore we did not adjust the lag from the value found by assuming that the upstream impoundments did not exist. The outflow hydrograph from Lake No. 2 is combined with the hydrograph of the runoff directly flowing into Lake No. 1 and routed to the outlet point.

b. Drainage area = 935 acres (includes 784 acres of area above several upstream impoundments).

c. Time of concentration:

$$T_c = (1.67)\ L$$

$$L = \frac{\ell^{0.8}(S+1)^{0.7}}{1{,}900Y^{0.5}}$$

L = lag in hours

$\ell$ = hydraulic length of watershed in feet

$S = \frac{1{,}000}{CN} - 10$ (where CN is the retardance factor and is equivalent to the runoff curve number)

Y = average watershed land slope in percent

$T_c$ = 0.34 hours (2)

d. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 88 for antecedent moisture condition III and a curve number of 74 for antecedent moisture condition II. The hydrologic soil groups in the basin were B and D (2 and 3).

e. The soil associations in this watershed are mainly Polo-Sogn and Sharpsburg Series (4).

2. Emergency spillway release rates are based on the level and unlevel weir equations.

Level weir equation:

$Q = CLH^{1.5}$ (C = 2.63, L = 10.5 feet, H is the head on weir)(5).

Principal spillway release rates are based on an assumed maximum discharge of 10 cfs.

Discharge rates over the top of the dam are based on the unlevel weir equation:

$$Q = \frac{2Cb}{5\ (h_b - h_a)}\ (h_b^{\,2.5} - h_a^{\,2.5})$$

(C = 2.60 = weir coefficient, b = the length of flow normal to the weir in feet, $h_b$ = the head of the low end of the weir in feet, and $h_a$ = the head of the high end of the weir in feet.) (6)

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour. Storage at various elevations was computed utilizing the conic method for computation of reservoir volume provided in HEC-1(1).

## BIBLIOGRAPHY


(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

(3) U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, January 1975.

(4) Mid America Regional Council, Regional Soils Guide, March 1976.

(5) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.

(6) U.S. Department of the Interior, Geological Survey, Techniques of Water-Resources Investigations, Book 3, Chapter A5, Measurement of Peak Discharge at Dams by Indirect Methods, by Harry Hulsing, 1967.

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************
      1          A1MISSOURI DAM INSPECTION PROGRAM
      2          A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
      3          A3KERNODLE LAKE DAM NOS. 1 & 2
      4          B     288       3       5       0       0       0       0       0       0       0
      5          B1      5
      6          J       1       2       1
      7          J1    .50     1.0
      8          K       0       1                               3       1
      9          K1   ESTIMATED ROUTED INFLOW FROM UPSTREAM IMPOUNDMENTS
     10          M       1       2    1.64                       1
     11          P            22.3     101     120     130
     12          T                                                       -1     -87
     13          W2            .85
     14          X                       1
     15          K       0       2                               3       1
     16          K1   INFLOW TO KERNODLE LAKE NO. 2
     17          M       1       2     .19                       1
     18          P            24.8     101     120     130
     19          T                                                       -1     -87
     20          W2            .22
     21          X                       1
     22          K       2       3                                       1
     23          K1   COMBINE INFLOW HYDROGRAPHS
     24          K       1       4                               3       1
     25          K1   ROUTE THROUGH KERNODLE LAKE NO. 2
     26          Y                               1       1
     27          Y1      1                                 -904.59      -1
     28          Y4904.59905.13  906.13  907.13  907.63  908.13  909.13  910.13  912.13
     29          Y50.      14.     75.    185.    319.    513.   1281.   2775.   9335.
     30          SA0.    18.8    27.4    32.9
     31          SE878.  904.6    920.    930.
     32          S$904.59
     33          SD906.78
     34          K       0       5                               3       1
     35          K1   INFLOW TO KERNODLE LAKE NO. 1
     36          M       1       2     .23                       1
     37          P            24.8     101     120     130
     38          T                                                       -1     -89
     39          W2            .20
     40          X                       1
     41          K       2       6                                       1
     42          K1   COMBINE NO. 1 & NO. 2 HYDROGRAPHS
     43          K       1       7                                       1
     44          K1   ROUTE THROUGH KERNODLE LAKE NO. 1
     45          Y                               1       1
     46          Y1      1                                 -887.13      -1
     47          Y4887.13888.32  888.13  889.13  890.63  891.13  892.13  894.13  896.13
     48          Y50.       4.      5.     46.    286.    900.   3645.  14620.  30304.
     49          SA0.      .8     3.3     14.    20.5    30.4     37.
     50          SE855.   860.    870.    880.    890.    900.    910.
```

| | |
|---|---|
| 51 | $SE87.13 |
| 52 | $D89v.05 |
| 53 | K 99 |

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

| OPERATION | STATION | AREA | PLAN | RATIO 1 .50 | RATIO 2 1.00 |
|---|---|---|---|---|---|
| | | | | RATIOS APPLIED TO FLOWS | |
| HYDROGRAPH AT | 1 | 1.04 | 1 | 2513. | 5026. |
| | ( | 2.69) | ( | 71.16)( | 142.31)( |
| HYDROGRAPH AT | 2 | .19 | 1 | 996. | 1993. |
| | ( | .49) | ( | 28.21)( | 56.43)( |
| 2 COMBINED | 3 | 1.23 | 1 | 2777. | 5553. |
| | ( | 3.19) | ( | 78.63)( | 157.26)( |
| ROUTED TO | 4 | 1.23 | 1 | 2720. | 5526. |
| | ( | 3.19) | ( | 77.02)( | 156.47)( |
| HYDROGRAPH AT | 5 | .23 | 1 | 1260. | 2519. |
| | ( | .60) | ( | 35.67)( | 71.34)( |
| 2 COMBINED | 6 | 1.46 | 1 | 3181. | 6857. |
| | ( | 3.78) | ( | 90.08)( | 194.16)( |
| ROUTED TO | 7 | 1.46 | 1 | 3060. | 6730. |
| | ( | 3.78) | ( | 86.65)( | 190.58)( |

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ...............

| | INITIAL VALUE | SPILLWAY CREST | TOP OF DAM |
|---|---|---|---|
| ELEVATION | 887.13 | 887.13 | 890.05 |
| STORAGE | 217. | 217. | 275. |
| OUTFLOW | 0. | 0. | 193. |

| RATIO OF PMF | MAXIMUM RESERVOIR W.S.ELEV | MAXIMUM DEPTH OVER DAM | MAXIMUM STORAGE AC-FT | MAXIMUM OUTFLOW CFS | DURATION OVER TOP HOURS | TIME OF MAX OUTFLOW HOURS | TIME OF FAILURE HOURS |
|---|---|---|---|---|---|---|---|
| .50 | 891.92 | 1.87 | 315. | 3063. | 10.92 | 16.00 | 0.00 |
| 1.00 | 892.69 | 2.64 | 333. | 6732. | 14.50 | 15.92 | 0.00 |

...............................

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************
A1MISSOURI DAM INSPECTION PROGRAM
A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
A3KERNODLE LAKE DAM NOS. 1 & 2
B    288       3       5       0       0       0       0       0       0       0
B1     5
J      1               4       1
J1.20       .15     .10     .05
K      0       1                               3       1
K1   ESTIMATED ROUTED INFLOW FROM UPSTREAM IMPOUNDMENTS
M      1       2    1.04                       1
P           19.8     101     120     130
T                                                     -1     -87
W2           .85
X                      1
K      3       2                               3       1
K1   INFLOW TO KERNODLE LAKE NO. 2
M      1       2     .19                       1
P           24.5     101     120     130
T                                                     -1     -87
W2           .22
X                      1
K      2       3                                       1
K1   COMBINE INFLOW HYDROGRAPHS
K      1       4                               3       1
K1   ROUTE THROUGH KERNODLE LAKE NO. 2
Y                              1       1
Y1     1                                   -904.59           -1
Y4904.59905.13  906.13  907.13  907.63  908.13  909.13  910.13  912.13
Y50.     14.     75.    185.    319.    513.   1281.   2775.   9335.
SA0.    18.8    27.4    32.9
SE874.  904.6   920.    930.
$$904.59
$D906.78
K      0       5                               3       1
K1   INFLOW TO KERNODLE LAKE NO. 1
M      1       2     .23                       1
P           24.8     101     120     130
T                                                     -1     -88
W2           .20
X                      1
K      2       6                                       1
K1   COMBINE NO. 1 & NO. 2 HYDROGRAPHS
K      1       7                                       1
K1   ROUTE THROUGH KERNODLE LAKE NO. 1
Y                              1       1
Y1     1                                   -887.13           -1
Y4887.13888.02  888.13  889.13  890.63  891.13  892.13  894.13  896.13
Y50.      4.      6.     46.    286.    900.   3645.  14620.  30304.
SA0.      .2     3.3     14.    20.8    30.4     37.
SE855.  860.    870.    880.    890.    900.    910.
```

| | |
|---|---|
| 51 | S$387.13 |
| 52 | S0393.05 |
| 53 | K 99 |

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

| OPERATION | STATION | AREA | PLAN | RATIO 1 .20 | RATIO 2 .15 | RATIO 3 .10 | RATIO 4 .05 |
|---|---|---|---|---|---|---|---|
| | | | | RATIOS APPLIED TO FLOWS | | | |
| HYDROGRAPH AT | 1 | 1.04 | 1 | 891. | 668. | 445. | 223. |
| | | ( 2.69) | | ( 25.23)( | 18.92)( | 12.61)( | 6.31)( |
| HYDROGRAPH AT | 2 | .19 | 1 | 399. | 299. | 199. | 100. |
| | | ( .49) | | ( 11.29)( | 8.46)( | 5.64)( | 2.83)( |
| 2 COMBINED | 3 | 1.23 | 1 | 997. | 748. | 499. | 249. |
| | | ( 3.19) | | ( 28.23)( | 21.17)( | 14.12)( | 7.06)( |
| ROUTED TO | 4 | 1.23 | 1 | 933. | 673. | 374. | 131. |
| | | ( 3.19) | | ( 26.43)( | 19.05)( | 10.60)( | 3.72)( |
| HYDROGRAPH AT | 5 | .23 | 1 | 504. | 378. | 252. | 126. |
| | | ( .60) | | ( 14.27)( | 10.70)( | 7.13)( | 3.57)( |
| 2 COMBINED | 6 | 1.46 | 1 | 1041. | 752. | 426. | 185. |
| | | ( 3.78) | | ( 29.49)( | 21.30)( | 12.07)( | 5.24)( |
| ROUTED TO | 7 | 1.46 | 1 | 1037. | 728. | 341. | 97. |
| | | ( 3.78) | | ( 29.36)( | 20.61)( | 9.67)( | 2.75)( |

## SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ...............

| | INITIAL VALUE | SPILLWAY CREST | TOP OF DAM |
|---|---|---|---|
| ELEVATION | 887.13 | 887.13 | 890.05 |
| STORAGE | 217. | 217. | 275. |
| OUTFLOW | 0. | 0. | 193. |

| RATIO OF PMF | MAXIMUM RESERVOIR W.S.ELEV | MAXIMUM DEPTH OVER DAM | MAXIMUM STORAGE AC-FT | MAXIMUM OUTFLOW CFS | DURATION OVER TOP HOURS | TIME OF MAX OUTFLOW HOURS | TIME OF FAILURE HOURS |
|---|---|---|---|---|---|---|---|
| .20 | 891.18 | 1.13 | 299. | 1037. | 6.50 | 16.67 | 0.00 |
| .15 | 890.99 | .94 | 295. | 729. | 5.42 | 16.92 | 0.00 |
| .10 | 890.68 | .63 | 289. | 341. | 3.92 | 17.92 | 0.00 |
| .05 | 889.45 | 0.00 | 262. | 97. | 0.00 | 19.50 | 0.00 |

```
*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
*********************************
   1         A1MISSOURI DAM INSPECTION PROGRAM
   2         A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
   3         A3KERNODLE LAKE DAM NOS. 1 & 2 - 100-YEAR FLOOD
   4         B    288     0     5     0     0     0     0     0     0     0
   5         B1     3
   6         K      0     1                       3     1
   7         K1  ESTIMATED ROUTED INFLOW FROM UPSTREAM IMPOUNDMENTS
   8         M      0     2  1.04                 1
   9         O    288
  10         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  11         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  12         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  13         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  14         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  15         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  16         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  17         01  .006  .006  .015  .015  .015  .015  .015  .015  .015  .015
  18         01  .015  .015  .015  .015  .015  .015  .015  .015  .015  .015
  19         01  .015  .015  .015  .015  .015  .015  .015  .015  .015  .015
  20         01  .015  .015  .015  .015  .015  .015  .015  .015  .028  .028
  21         01  .028  .028  .028  .028  .028  .028  .029  .029  .028  .028
  22         01  .028  .028  .028  .028  .028  .028  .029  .029  .029  .029
  23         01  .029  .029  .065  .065  .065  .065  .065  .065  .152  .153
  24         01  .153  .290  .290  .573  .543  .378  .290  .153  .152  .153
  25         01  .065  .065  .065  .065  .065  .065  .029  .029  .029  .029
  26         01  .029  .029  .028  .028  .028  .028  .028  .029  .029  .028
  27         01  .028  .028  .028  .028  .028  .029  .029  .029  .028  .029
  28         01  .015  .015  .015  .015  .015  .015  .015  .015  .015  .015
  29         01  .015  .015  .015  .015  .015  .015  .015  .015  .015  .015
  30         01  .015  .015  .015  .015  .015  .015  .015  .015  .015  .015
  31         01  .015  .015  .015  .015  .015  .015  .006  .006  .006  .006
  32         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  33         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  34         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  35         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  36         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  37         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  38         01  .006  .006  .006  .006  .006  .006  .006  .005
  39         T                                        -1   -73
  40         W2         2.66
  41         X                      1
  42         K      0     2                       3     1
  43         K1  INFLOW TO KERNODLE LAKE NO. 2
  44         M      0     2   .19                 1
  45         O    288
  46         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  47         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  48         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  49         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
  50         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006

  51         01  .006  .006  .006  .006  .006  .006  .006  .006  .006  .006
```

```
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .015   .015   .015   .015   .015   .015   .015   .015
01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
01  .015   .015   .015   .015   .015   .015   .015   .015   .028   .028
01  .028   .028   .028   .028   .028   .028   .028   .028   .028   .028
01  .028   .028   .028   .028   .028   .028   .029   .029   .029   .029
01  .029   .029   .065   .065   .065   .055   .065   .065   .152   .152
01  .153   .290   .290   .573   .843   .798   .290   .153   .153   .153
01  .065   .065   .065   .065   .055   .055   .029   .029   .029   .029
01  .029   .029   .028   .028   .028   .028   .028   .028   .028   .028
01  .028   .028   .028   .028   .023   .028   .028   .028   .028   .028
01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
01  .015   .015   .015   .015   .015   .015   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006
T                                           -1     -73
W2           .34
X                   1
K     2      3                                     1
K1    COMBINE INFLOW HYDROGRAPHS
K     1      4                              3      1
K1    ROUTE THROUGH KERNODLE LAKE NO. 2
Y                          1      1
Y1    1                                    -904.59        -1
Y4904.59905.13  906.13  907.13  907.63  908.13  909.13  910.13  912.13
Y50.     14.     75.     185.    319.    513.    1281.   2775.   9335.
$A0.     18.8    27.4    32.9
$E578.   904.6   920.    936.
$$904.59
$D906.78
K     0      5                              3      1
K1    INFLOW TO KERNODLE LAKE NO. 1
M     0      2      .23                     1
O     263
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
```

```
101    01  .006   .006   .015   .015   .015   .015   .015   .015   .015   .015
102    01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
103    01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
104    01  .015   .015   .015   .015   .015   .015   .015   .015   .028   .028
105    01  .028   .028   .028   .028   .023   .028   .023   .023   .045   .023
106    01  .026   .028   .029   .023   .023   .023   .029   .029   .029   .029
107    01  .029   .029   .065   .065   .065   .065   .065   .065   .152   .153
108    01  .153   .290   .290   .573   .843   .398   .290   .153   .153   .153
109    01  .065   .065   .065   .065   .065   .065   .029   .029   .029   .029
110    01  .029   .029   .028   .028   .028   .023   .029   .028   .028   .028
111    01  .028   .028   .028   .028   .028   .028   .028   .028   .028   .029
112    01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
113    01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
114    01  .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
115    01  .015   .015   .015   .015   .015   .015   .006   .006   .006   .006
116    01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
117    01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
118    01  .006   .006   .006   .006   .005   .006   .006   .006   .006   .006
119    01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
120    01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
121    01  .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
122    01  .006   .006   .006   .006   .006   .006   .005   .006
123    T                                                   -1     -74
124    W2          .31
125    X                       1
126    K      2      6                                      1
127    K1  COMBINE NO. 1 & NO. 2 HYDROGRAPHS
128    K      1      7                                      1
129    K1  ROUTE THROUGH KERNODLE LAKE NO. 1
130    Y                                     1      1
131    Y1     1                                      -887.13       -1
132    Y4887.13888.02  888.13  889.13  890.63  891.13  892.13  894.13  896.13
133    Y50.      4.      6.     46.    286.    900.   3645.  14620.  33334.
134    SA0.     .8     3.3     14.    20.9    30.4     37.
135    SE855.  860.    870.    880.    890.    900.    910.
136    $SE87.13
137    $D890.05
138    K     99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

| | | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | AREA |
|---|---|---|---|---|---|---|
| HYDROGRAPH AT | 1 | 574. | 381. | 120. | 120. | 1.04 |
| | ( | 16.27)( | 10.80)( | 3.40)( | 3.40)( | 2.69) |
| HYDROGRAPH AT | 2 | 407. | 78. | 23. | 23. | .19 |
| | ( | 11.52)( | 2.20)( | .65)( | .65)( | .49) |
| 2-COMBINED | 3 | 609. | 438. | 143. | 143. | 1.23 |
| | ( | 17.26)( | 12.42)( | 4.05)( | 4.05)( | 3.19) |
| ROUTED TO | 4 | 568. | 381. | 126. | 126. | 1.23 |
| | ( | 16.08)( | 10.78)( | 3.57)( | 3.57)( | 3.19) |
| HYDROGRAPH AT | 5 | 520. | 96. | 29. | 29. | .23 |
| | ( | 14.74)( | 2.72)( | .81)( | .81)( | .60) |
| 2-COMBINED | 6 | 599. | 424. | 155. | 155. | 1.46 |
| | ( | 16.95)( | 12.00)( | 4.39)( | 4.39)( | 3.78) |
| ROUTED TO | 7 | 579. | 380. | 130. | 130. | 1.46 |
| | ( | 16.38)( | 10.76)( | 3.67)( | 3.67)( | 3.78) |

SUMMARY OF DAM SAFETY ANALYSIS

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ...............

100-YR.

| | INITIAL VALUE | SPILLWAY CREST | TOP OF DAM |
|---|---|---|---|
| ELEVATION | 887.13 | 887.13 | 890.05 |
| STORAGE | 217. | 217. | 275. |
| OUTFLOW | 0. | 0. | 193. |

| RATIO OF PMF | MAXIMUM RESERVOIR W.S.ELEV | MAXIMUM DEPTH OVER DAM | MAXIMUM STORAGE AC-FT | MAXIMUM OUTFLOW CFS | DURATION OVER TOP HOURS | TIME OF MAX OUTFLOW HOURS | TIME OF FAILURE HOURS |
|---|---|---|---|---|---|---|---|
| .20 | 890.87 | .82 | 292. | 579. | 7.42 | 15.75 | 0.00 |

**********************************

FLOOD HYDROGRAPH PACKAGE (HEC-1)

```
*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************
                  A1MISSOURI DAM INSPECTION PROGRAM
                  A2ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
                  A3KERNODLE LAKE DAM NOS. 1 & 2 - 10-YEAR FLOOD
                  B     288      0      5      0      0      0      0      0      0      0
                  B1      3
                  K       0      1                    3      1
                  K1   ESTIMATED ROUTED INFLOW FROM UPSTREAM IMPOUNDMENTS
                  M       0      2   1.04                    1
                  O     288
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .010   .010   .010   .010   .010   .010   .010   .010
                  O1   .010   .010   .010   .010   .010   .010   .010   .010   .010   .010
                  O1   .010   .010   .010   .010   .010   .010   .010   .010   .010   .010
                  O1   .010   .010   .010   .010   .010   .010   .010   .010   .015   .015
                  O1   .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
                  O1   .015   .015   .015   .015   .015   .015   .029   .029   .029   .029
                  O1   .029   .029   .050   .050   .050   .050   .050   .050   .098   .099
                  O1   .099   .187   .187   .390   .594   .271   .187   .099   .099   .098
                  O1   .050   .050   .050   .050   .050   .050   .029   .029   .029   .029
                  O1   .029   .029   .015   .015   .015   .015   .015   .015   .015   .015
                  O1   .015   .015   .015   .015   .015   .015   .015   .015   .015   .015
                  O1   .010   .010   .010   .010   .010   .010   .010   .010   .010   .010
                  O1   .010   .010   .010   .010   .010   .010   .010   .010   .010   .010
                  O1   .010   .010   .010   .010   .010   .010   .010   .010   .010   .010
                  O1   .010   .010   .010   .010   .010   .010   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005
                  T                                                 -1    -77
                  W2          2.66
                  K                     1
                  K       0      2                    3      1
                  K1   INFLOW TO KERNODLE LAKE NO. 2
                  M       0      2    .19                    1
                  O     288
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
                  O1   .005   .005   .005   .005   .005   .005   .005   .005   .005   .005
```

```
51     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
52     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
53     01 .005  .005  .010  .010  .010  .010  .010  .010  .010  .010
54     01 .010  .010  .010  .010  .010  .010  .010  .010  .010  .010
55     01 .010  .010  .010  .010  .010  .010  .010  .010  .010  .010
56     01 .010  .010  .010  .010  .010  .010  .010  .010  .015  .015
57     01 .015  .015  .015  .015  .015  .015  .015  .015  .015  .015
58     01 .015  .015  .015  .015  .015  .015  .029  .029  .029  .029
59     01 .029  .029  .050  .050  .050  .050  .050  .050  .098  .099
60     01 .099  .187  .187  .390  .594  .271  .187  .099  .099  .098
61     01 .050  .050  .050  .050  .050  .050  .029  .029  .029  .029
62     01 .029  .029  .015  .015  .015  .015  .015  .015  .015  .015
63     01 .015  .015  .015  .015  .015  .015  .015  .015  .015  .015
64     01 .010  .010  .010  .010  .010  .010  .010  .010  .010  .010
65     01 .010  .010  .010  .010  .010  .010  .010  .010  .010  .010
66     01 .010  .010  .010  .010  .010  .010  .010  .010  .010  .010
67     01 .010  .010  .010  .010  .010  .010  .005  .005  .005  .005
68     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
69     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
70     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
71     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
72     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
73     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
74     01 .005  .005  .005  .005  .005  .005  .005  .005
75     T                                       -1    -73
76     W2          .34
77     X                    1
78     K     2     3                            1
79     K1    COMBINE INFLOW HYDROGRAPHS
80     K     1     4                      3     1
81     K1    ROUTE THROUGH KERNODLE LAKE NO. 2
82     Y                          1     1
83     Y1    1                         -904.59      -1
84     Y4904.59905.13  906.13  907.13  907.63  908.13  909.13  910.13  912.13
85     Y50.   14.     75.    185.    319.    513.    1281.   2775.   9335.
86     $A0.   18.8    27.4    32.9
87     $E873.  904.6   920.    930.
88     $$904.59
89     $D926.78
90     K     0     5                      3     1
91     K1    INFLOW TO KERNODLE LAKE NO. 1
92     M     0     2     .23              1
93     O   288
94     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
95     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
96     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
97     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
98     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
99     01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005
100    01 .005  .005  .005  .005  .005  .005  .005  .005  .005  .005

101    01 .005  .005  .010  .010  .010  .010  .010  .010  .010  .010
102    01 .010  .010  .010  .010  .010  .010  .010  .010  .010  .010
```

```
101   01 .005 .005 .010 .010 .010 .010 .010 .010 .010 .010
102   01 .010 .010 .010 .010 .010 .010 .010 .010 .010 .010
103   01 .010 .010 .010 .010 .010 .010 .010 .010 .010 .010
104   01 .010 .010 .010 .010 .010 .010 .010 .010 .015 .015
105   01 .015 .015 .015 .015 .015 .015 .015 .015 .015 .015
106   01 .015 .015 .015 .015 .015 .015 .029 .029 .029 .029
107   01 .029 .029 .050 .050 .050 .050 .050 .050 .099 .099
108   01 .099 .157 .187 .390 .594 .271 .187 .099 .099 .099
109   01 .050 .050 .050 .050 .050 .050 .029 .029 .029 .029
110   01 .029 .029 .015 .015 .015 .015 .015 .015 .015 .015
111   01 .015 .015 .015 .015 .015 .015 .015 .015 .015 .015
112   01 .010 .010 .010 .010 .010 .010 .010 .010 .010 .010
113   01 .010 .010 .010 .010 .010 .010 .010 .010 .010 .010
114   01 .010 .010 .010 .010 .010 .010 .010 .010 .010 .010
115   01 .010 .010 .010 .010 .010 .010 .005 .005 .005 .005
116   01 .005 .005 .005 .005 .005 .005 .005 .005 .005 .005
117   01 .005 .005 .005 .005 .005 .005 .005 .005 .005 .005
118   01 .005 .005 .005 .005 .005 .005 .005 .005 .005 .005
119   01 .005 .005 .005 .005 .005 .005 .005 .005 .005 .005
120   01 .005 .005 .005 .005 .005 .005 .005 .005 .005 .005
121   01 .005 .005 .005 .005 .005 .005 .005 .005 .005 .005
122   01 .005 .005 .005 .005 .005 .005 .005 .005
123   T                                   -1   -74
124   W2        .31
125   X                   1
126   K      2    6                        1
127   K1  COMBINE NO. 1 & NO. 2 HYDROGRAPHS
128   K      1    7                        1
129   K1  ROUTE THROUGH KERNODLE LAKE NO. 1
130   Y                          1    1
131   Y1     1                         -887.13   -1
132   Y4387.13888.02  888.13  889.13  890.63  891.13  892.13  894.13  896.13
133   Y50.    4.      6.      46.     286.    920.    3645.   14620.  30334.
134   SAV.    .8      3.3     14.     20.8    33.4    37.
135   SE855.  860.    870.    880.    890.    900.    910.
136   $$387.13
137   $D890.05
138   K      99
```

RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

| | | PEAK | 6-HOUR | 24-HOUR | 72-HOUR | AREA |
|---|---|---|---|---|---|---|
| HYDROGRAPH AT | 1 | 315. | 210. | 65. | 66. | 1.04 |
| | ( | 9.00)( | 5.94)( | 1.84)( | 1.88)( | 2.69) |
| HYDROGRAPH AT | 2 | 223. | 43. | 13. | 13. | .19 |
| | ( | 6.31)( | 1.22)( | .37)( | .37)( | .49) |
| 2-COMBINED | 3 | 334. | 240. | 79. | 79. | 1.23 |
| | ( | 9.47)( | 6.80)( | 2.24)( | 2.24)( | 3.19) |
| ROUTED TO | 4 | 253. | 185. | 65. | 65. | 1.23 |
| | ( | 7.18)( | 5.23)( | 1.85)( | 1.85)( | 3.19) |
| HYDROGRAPH AT | 5 | 289. | 54. | 16. | 16. | .23 |
| | ( | 8.19)( | 1.53)( | .46)( | .45)( | .60) |
| 2-COMBINED | 6 | 300. | 201. | 82. | 82. | 1.46 |
| | ( | 8.49)( | 5.69)( | 2.31)( | 2.31)( | 3.78) |
| ROUTED TO | 7 | 204. | 176. | 59. | 59. | 1.46 |
| | ( | 5.78)( | 4.98)( | 1.66)( | 1.66)( | 3.78) |

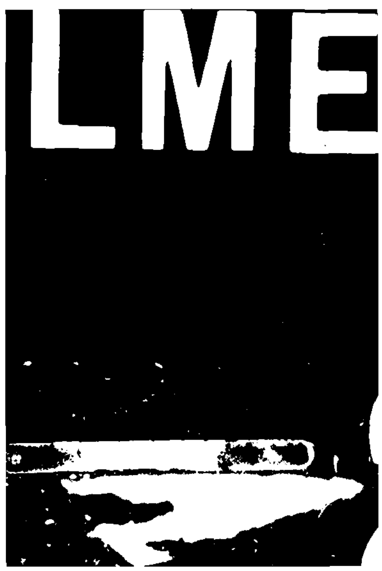
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ...............

| | INITIAL VALUE | SPILLWAY CREST | TOP OF DAM |
|---|---|---|---|
| ELEVATION | 887.13 | 887.13 | 890.05 |
| STORAGE | 217. | 217. | 275. |
| OUTFLOW | 0. | 0. | 193. |

10-YR.

| RATIO OF PMF | MAXIMUM RESERVOIR W.S.ELEV | MAXIMUM DEPTH OVER DAM | MAXIMUM STORAGE AC-FT | MAXIMUM OUTFLOW CFS | DURATION OVER TOP HOURS | TIME OF MAX OUTFLOW HOURS | TIME OF FAILURE HOURS |
|---|---|---|---|---|---|---|---|
| .23 | 890.12 | .07 | 276. | 204. | 1.92 | 17.42 | 0.00 |


LME